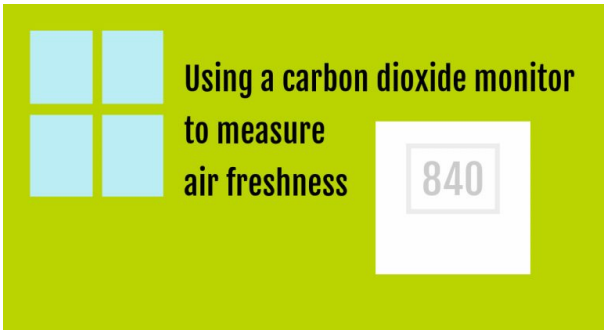
Using a carbon dioxide monitor to measure air freshness

31 December 2021 by Jennifer

Explanation of an ingenious thing: how you can use a CO_2 monitor to check the air-freshness in a room, to guide your covid risk reduction.

I looked into this a while ago and I thought I'd do a write-up!



What we can measure

Wouldn't it be useful if we could somehow **measure** "Has this room got any **covid particles** hanging in the air at the moment?"?

Unfortunately, we **can't yet do that in real-time**. When scientists wanted to measure the covid levels in hospital ward air, they had to gather the samples first, then take them back to the lab and do some extra processes to find out what they'd actually gathered. They commented "The sampling and detection of airborne viruses poses several technological challenges" :-)

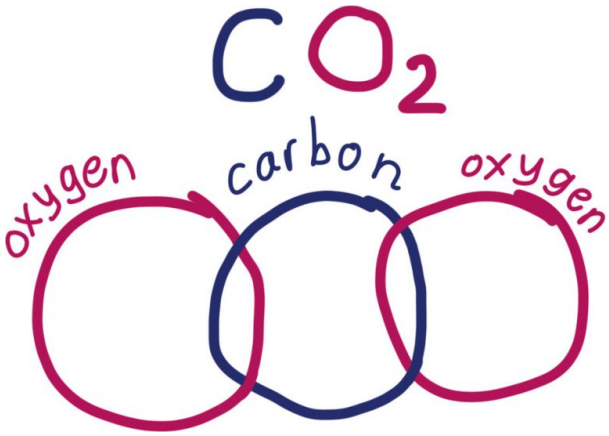
On the other hand, measuring *carbon dioxide* in the air is something people have been doing for ages. And that can give us a **clue** about what the **covid risks** might be in a particular space.

What is carbon dioxide and why is it relevant?

(Skip if you know this bit :-))

Carbon dioxide is one of the gases which we naturally breathe out in our breath. We breathe in oxygen, our bodies make use of it, and we breathe out carbon dioxide.

You'll often hear it referred to as CO_2, "see oh two". The C means "carbon atom". The O_2 means "oxygen atoms, two of them". They link up to make a molecule with the carbon atom in the middle. (The "di" in "dioxide" means two, as well.)



If CO_2 builds up in a room, we sometimes sense that as the room becoming "stuffy". If you ever felt sleepy in a stuffy room, then more refreshed after someone opened a window… part of that was probably the fresh oxygen coming in, and the breeze sweeping away some of the built-up CO_2.

Virus in breath

Meanwhile…

As you might know by now, someone currently infected with covid can **breathe out covid virus on their breath**. The teeny tiny particles of breath-liquid, with even tinier specks of virus in them, can **hang in the air** for some time. In still air, they might hang about for a few hours – though obviously they'd get blown away

much quicker than that if you were outdoors.

Then the next person breathes in that same bit of air, and that's probably the number one way that covid gets from one person to the next.

Fresh air will tend to sweep away any germs that are floating around – either from someone *in* the room, or from someone who already left the room a while ago.

(Even outdoors or in a well-ventilated room, you could still pick up germs from the breath of people close to you, same as you'd smell the smoke if someone was smoking right next to you. That's why we still need good, face-fitting masks sometimes *as well as* fresh air. But the fresh air really helps.)

Making the connection

The ingenious idea was: OK, we can't measure covid itself. But both covid virus and CO_2 molecules float in human breath! So we can measure **how much *carbon dioxide* is building up** in a room, or bus, or train carriage, or hospital ward, as the people there are breathing. And that would give us a clue to **how much covid virus *would* typically build up** in that space, supposing an infectious person were there.

If a lot of CO_2 is building up, it's a clue that a lot of covid virus could build up in that room too, if anyone there was infected. And the other way round: if the CO_2 level is *low* while people are there, then plenty of fresh air must be coming in to carry away what the humans are breathing out.

It's what in science terms would be called a "**proxy measure**": not *exactly* the same thing as what you're really interested in, but related (at least some of the time) in a useful way.

Example of a CO_2 monitor

The Aranet 4 Home has been recommended (by scientists I consider reputable) as a good-quality CO_2 meter. It uses a "nondispersive infrared" sensor, more accurate than some of the other kinds.

It's a dinky little thing – about 7cm by 7cm on its front face, similar to the palm of a smallish hand. It would easily fit in a pocket, and has a hole in the back where you can hang it over a screw-head on the wall.

Via Bluetooth, you can link one or more units to your phone, and view the results in an app which you can download for free. The app can memorise 7 days' worth of how the levels went up or down, for you to look at afterwards.

Cost of that Aranet one is €199.00 plus taxes & delivery: expensive for the average family, but not enormous compared to running a school, a hospital or a business.

There are cheaper ones too. If you're getting one, make sure it's the "**nondispersive infrared**" type, also known as **NDIR**.

This *kind* of thing is what the UK government has promised to UK

schools, although I don't know if they're buying the Aranet or a different model.

What number to aim for

The CO_2 level in air is measured in "parts per million", often written "ppm".

(Little devices like this won't measure it to an exact number – it'll be more like "give or take 50ppm", which is good enough for ventilation monitoring.)

Outdoor air would typically read at about **400ppm** to **450ppm**, or higher if you're near a busy road.

What's a "good" level?

A study looking at a tuberculosis outbreak found the outbreak stopped after the ventilation was improved enough that the CO_2 level went down to **600ppm**. Getting it below **1,000ppm** also made a significant difference to the chance of infection. (Summarised here.)

Tuberculosis and covid both transmit via floating in the air, so we could make a guess that similar levels might be good for covid too. So it would make sense to say **600ppm is good to aim for**. But if you can't get it *that* low, 700ppm is better than 800ppm, 800ppm is better than 900ppm and so on.

The excellent *FAQs on Protecting Yourself from Aerosol Transmission*, by a group of top professors, summed up like this:

> The exact level considered "safer" for CO_2 varies and we have seen various recommendations from 500 to 950 ppm.
>
> Choosing a general level like this is a compromise to make the method feasible and simple enough for many people. This is the same reason that a single distance (e.g. 1 m or 2 m) is quoted for social distancing (even though we know that 1.5 m is better than 1 m, and 2 is better than 1.5 m etc.).
>
> *A key goal is to make clear that the many shared spaces*

> *with 2000 or 3000 ppm CO_2 are unsafe, so that people realize that they have to take action to improve the situation there.*
>
> Surveying classrooms, offices etc. with a CO_2 monitor can be useful to determine which ones may have the worst ventilation, and prioritizing our actions there.

(paragraph breaks added by me for ease of reading)

They also explain:

- ~800 ppm, 1% of the air you are breathing has already been breathed by someone in the space. This can start to be risky.
- ~4400 ppm, 10% of the air you are breathing has already been breathed by someone else. This is a very dangerous situation. Levels this high are commonly observed in densely occupied spaces with low ventilation such as many schools.

Fresh air helps thinking too

Aside from *infection* risks in stale air, there's been a lot of research into how CO_2 itself affects human functioning. Levels over 1,000ppm are associated with things like headaches, asthma and not thinking as clearly. For example,

> Thirty male active commercial airline pilots performed three 3-h flight simulations on the flight deck at 700, 1500, 2500 ppm CO_2. … the pilots were more likely to successfully perform five of the seven most difficult maneuvers at the lower CO_2 concentration.

In the experiment with the pilots, only the CO_2 level itself was changed. In *similar* experiments, the dozy effect wasn't always narrowed down to CO_2 in particular: if you're just looking at "stale air" overall, then the effects can also be from other molecules building up in a room over time, e.g. from paint or furniture. But either way, fresh air was better.

So this kind of research had already made pretty clear that fresh air helps with health and thinking. Places like schools should arguably aim for below 1,000ppm of CO_2 for *that* reason, even aside from covid risk.

What the measurement is useful for

Of course, **finding out** the air is "too stale" **doesn't actually *fix* the air**! It's just a clue.

The meter can be useful for answering

- Would it be a good idea to open the window for a while?
- Opening the window in here is definitely enough when there's a breeze, but what about on a day when the air is still?
- Does this classroom need an air filter as well, because opening the windows isn't doing enough?

If you can't get a monitor to use every day, you might at least try to borrow one for a trial sometimes, to get a sense of how well-aired your space *typically* is.

Informing choices

In some contexts, the CO_2 information can enable people to choose whether to enter the space at all. For instance, this photo from @NOGjp shows a real-time display board in the entrance lobby of a cinema in Japan, in July 2021. Each segment of the chart represents the CO_2 level in one of the cinema rooms.